My Eureka Moment

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As engineers, we do a lot of solid and useful work during our working lives. The opportunity to create truly path breaking and innovative products or services, comes rarely. Let me share one such moment from a career spanning over five decades.

I joined the Navy after completing my degree in Naval Architecture from IIT Kharagpur. Navy deputed me to UK to attend a prestigious four year course on warship design. Five years later, I got the rare opportunity of working in the Royal Navy Design offices Bath for a year in 1967-8, as part of the Leander Frigate Project, for warships to be built under license from the UK. .

Six frigates were built n Mazagon Docks Limited over the next twelve years. The Nilgiri class- INS Niligiri, Himgiri, Udaygiri, Dunagiri,Taragiri and Vindhyagiri were the first full-fledged warships built in India. I was closely associated with the project as a designer, introducing major changes, including localization of air conditioning in the ships and accommodation of a larger HAL built Helicopter “Alouette” on the ships. The project gave India the basic skills for warship construction and the ability to make major design changes. The next major step for us was to develop a totally Indian design warship to meet specific requirements of Indian Navy.

Work started in 1974 on the follow-on frigates (later named Godavari Class), which were larger than the Giris and carried surface to air and surface to surface missiles for the first time in India. We were required to develop ab-initio a larger frigate, which combined western underwater weapons and Soviet surface weapons in one hull, for the first time in the world.

The Indian naval staff realized that the requirements for surface to surface and surface to air missiles, improved helicopter availability and greater fire power, could not just be accommodated in the Leander hull. This was apparent by the time the construction of the sixth frigate of the Leander class was taken up. The staff also wanted the ship to travel over knot faster, over 29 knots for strategic reasons. Quick studies revealed that the ship had to be a good 12 meters longer and would weigh 600 tons more than the largest Indian Leanders, Vindhyagiri and Taragiri. The need was for a bigger and faster ship.

This called for the complete design of a new major warship. I was finally assigned the task for which I had equipped myself for years. In 1974, I was appointed as the project officer in charge of INS Godavari class of ships, then code-named project 16.

The Navy then took the daring decision of importing missile systems and guns from the Soviet Union and incorporating Western underwater weapons in the ship. Such an exercise of marrying Soviet origin weapons and western origin weapons in the same ship had never been tried before and has also never been done successfully in any other navy except ours. Many a doubting Thomas felt that the naval designers were not capable of designing such a ship and wanted to import the ships from abroad.

As the project in charge I was assigned the task of coordinating and producing the basic ship design. Also as a hull specialist, I was responsible for the lines of the vessel; layout, structural design, propellers, and major systems like air conditioning. We decided to use metric units in the project from the beginning, in line with national policy.

The Giris displaced about 3000 tons and had a top speed of about 28 knots. The Naval staff demanded a minimum one knot extra from the ships which were estimated to weigh about 3600 tons and be about 123 meters (40 feet) longer. The Leander was propelled by two steam turbines of 15000 shaft horsepower each. Naval marine engineers of the Navy wanted to fit gas turbines, which we had never used in a new design before.

A bigger and longer ship, designed to go faster would obviously need more power, as per conventional wisdom. So the search was on for a larger power plant

On a wet Saturday afternoon I was doodling on a piece of paper at home and idly wondered "what would happen, if I powered the new ship with the same power plant- two turbines of fifteen thousand horsepower each, without any change. How much would the speed drop? Was there any chance of convincing the naval staff that a small sacrifice in top speed would make the ship more economical and easier to construct?" I did a back-of-the envelope calculation to estimate the speed loss. To my utter surprise, the answer came out that the ship did not lose speed at all. On the contrary it would go a full knot faster, at 29 knots which the naval staff wanted! I checked the numbers again and again and could not find any mistakes in the calculation. The power required and found that the answer came out the same. I was elated. Perhaps this was a brilliant solution for meeting the navy's requirement without any additional investment, using equipment being manufactured in India. I was so excited about my discovery that I could hardly sleep the whole weekend.

I rushed to the office on Monday and announced my discovery. No one believed me at first. I was greeted with a stony silence. Most of my colleagues, thought that I had gone out of my head. I could not blame them, as my findings were totally counter-intuitive. My boss insisted that another officer should check the numbers. Lo and behold, the answer was the same. We realized that we could preserve the steam turbine power plant of Leander class frigates and meet the naval staff's requirement for higher speed.

We had to find the reason for this windfall benefit. A detailed analysis showed that below twenty-two knots speed, the larger ship required more power for the same speed as the Leander. At around twenty-two knots, both ships required the same power but above 22 knots, the bigger ship required less power. Again above 31 knots, the bigger vessel again as at a disadvantage compared to the Leander class ships. But happily, at 29 knots plus, the larger ship needed only the same power as the Leander's s 30000 HP. Fortunately a happy combination of the laws of hydrodynamics was working to our advantage.

Above 22 knots, the resistance to motion from wave making due to the ship cleaving through the sea became much more prominent than friction. If the interference between the waves created by the bow (front) of the ship and the stern (rear) of the ship were positive, resulting in a crest at the rear end, resistance due to wave making would be lower. If the interference between the bow and stern wave systems resulted in a trough at the stern, the resistance due to wave making would be higher. The interference is a function of Froude number, which related the square of the speed of the ship to the length of the ship. In the case of the Leander at 28 knots, the interference caused a trough at the stern increasing the wave making resistance. But in the new longer ship, the interference resulted in a crest. This resulted in a lower wave resistance in the bigger ship, which more than compensated the increased drag due to greater area.

Once we had done this analysis the picture became a lot clearer. In nature, as in life, however, there is no free lunch. While we could reach the top speed comfortably with the same engines, at the normal cruising speeds the ship consumed twenty percent more fuel than the Leander. We had to increase the fuel tank capacity of the ship.

My discovery enabled us to use the same power plant, gearing, transmission and even propeller as the Leander in the new ships, saving immense design effort and costs. Moreover, Mazagon Docks had experience of construction of six Leander class ships with the same power plant and the learning.

When we announced our findings to the naval staff, the marine engineering fraternity of the Navy was up in arms questioning the validity of my calculations. I stuck to my guns staking my professional reputation on my calculations. The top naval brass supported me and the Godavari class frigates were designed round existing steam turbines only.

By physically locating all machinery spaces, diesel alternator rooms, boiler room, engine room, stern compartments and propeller shaft supports and the propeller supporting bracket at the same relative locations and distances as in the original Leanders, substantial amount of engineering redesign was averted. These were major decisions, which I was personally responsible for. To some extent, my lack of experience and data turned out to be a major asset, as I was not constrained by past practice, which often works against innovations.

The Godavari design group had a great time designing the ship. Each day threw up fresh challenges and problems and revealed exciting solutions. The designers were young and inexperienced but incredibly committed. The whole group was working in a fever pitch of self-actualization. The mood was similar to a jugalbandi of Ravi Shankar and Ali Akbar khan or a tabla duo performance of Allah Rakha and Zakhir Hussain.

To confirm our findings, we carried out scale model tests for propulsion and sea keeping of the hull form at the renowned National Physical Laboratory in the UK. The tests were successful. They vindicated my original assertion that we could achieve over 29 knots speed in the larger ship with the same power plant as the Leanders. The sea-keeping qualities of the ship were also excellent, providing a very stable platform even under rough sea conditions. I completed the structural drawings and major layouts of the ship during my tenure.

For the work I had done on the project, I was recommended for the Vishist Seva Medal (Distinguished Service Medal) and was awarded the same in the republic day Jal Cursetjee, in an impressive ceremony held in Bombay.

Six years later the first ship of the class INS Godavari achieved over 29 knots during sea trials. .

Six ships of the class have been delivered to the Navy.   The savings in machinery costs alone were over two thousand crores of rupees. Precious Forex was saved at a time of low reserves Using known aggregates speeded up design and I had proved that a heavier faster ship could travel faster with the same power plant. My innovation was vindicated. .